



Design strategies for the development of mHealth services in healthcare of adolescents with cancer

Amanta Karpathaki, Anna Sargianou

MSc Program "Strategies of Developmental and Adolescent Health", Medical School of Athens, National and Kapodistrian University of Athens, Greece.

ABSTRACT

During the developmental stage of adolescence, profound physical, cognitive, and emotional changes occur, thus making adolescent cancer patients a population that seemingly have unique needs for support and treatment. Health-related difficulties have been effectively addressed by the use of portable and accessible technology interventions. Adolescents may benefit from mobile health (mHealth) applications that highlight the significance of their integration into medical procedures and public health, due to their innate capacity to use modern technology services. After reviewing 31 articles, it appears that well-designed mHealth practices have the potential to enhance the long-term devotion of the user to the received intervention. MHealth tools seem to incorporate widely applied theories such as Behavior Change Theory, User centered Design, Social Marketing Theory, Social Cognitive Theory, Self-Determination Theory and Narrative Transportation Theory, in order to increase patients' engagement with the main purpose of behavioral change. The aforementioned theoretical frameworks include engaging strategies such as developmentally accepted content, rewards, customization, user feedback, time-appropriate intervention delivery, multimedia provision, ease to use and therapeutically designed games that could be implemented in mHealth interventions for adolescents with a cancer diagnosis. Both the theoretical structure and the engaging characteristics present a few limitations. These are discussed at the end of this review along with potential future research suggestions in order to improve the design procedures of mHealth services applied in adolescents with cancer, intending to optimize health-related behavior.

Key Words: *mobile health, adolescents, young adults, cancer, application design, engagement*

Corresponding Author: Amanta Karpathaki email: amanda25111998@gmail.com

Introduction

Adolescent cancer

Around 14,000 cases of cancer in teenagers and young adults are reported each year in Europe (1). According to the World Health Organization, (WHO) adolescence is defined between the ages of 10 to 19, acknowledging that this age range is flexible and depends on a variety of social, biological, socioeconomic, and gender factors(2). Adolescence is a unique stage that presents distinct developmental and psychological traits and marks the transition from childhood to adulthood (2). Accordingly, from the moment of diagnosis, throughout the treatment, and after recovery as cancer survivors, this population has specific care needs that require individualized support (1).

Many factors justify the differentiation of adolescents and young adults (AYAs) with cancer from other age groups, such as children and older adults (3). Firstly, the epidemiology of cancer in this population differs, as 10% of observed tumors are mainly pediatric, while 30% peak in adolescence. In particular, these rates include Hodgkin's lymphoma, Ewing's sarcoma, osteosarcoma, germ cell tumors and, more rarely, soft tissue sarcomas, with the remaining cases referring to early adult cancers (3-6). In fact, some types of cancer appear to occur frequently in adolescents with lower survival rates, compared to data found in the child and adult populations (6,7).

Mobile Health

Mobile Health (mHealth) is defined by W.H.O. as "the medical practice and public health practice supported by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants and other wireless devices" (6). It incorporates the usage of mobile and wireless applications (e.g. SMS text messages, applications, mobile devices and the use of social media) aiming to provide health-related services (3). MHealth tools seem to have received broad recognition in recent years, especially in the children and adolescents population (7). Ramsey et al. (7) in their meta-analysis supported that a percentage as high as 95% of adolescents reported owning or accessing a mobile phone, 73% to a smartphone and 87% to a desktop or laptop (7). In addition, in recent studies it was estimated that 95% of 13-17 years old own or have access to a smartphone, which they often carry with them and use regularly to stay online (7).

It would be constructive to implement such applications into regular care of adolescents with cancer since they are often characterized as digital natives and are familiar with modern devices (6). Researchers indicate that children and adolescents seem to underestimate the traditional hand

-written forms of interventions and are more willing to use mHealth devices while having more capabilities in learning their usage (8). Regardless of the fact that mHealth interventions seem to be a pole of attraction for AYAs, studies have supported that only 2% of them use a mHealth application usually (6). Despite the variety of existing applications and the expanded growth of mHealth interventions, only a quarter of them that have been downloaded are being used just once (4). Noteworthy, it has been estimated that populations from lower socioeconomic status have limited access to modern technology, using smartphones up to 25%, which could result in selection bias regarding the benefits of mHealth practices (5).

Achieving optimal success of mHealth interventions, characteristics such as staying connected and being familiar with modern technology seem to be inadequate (6). Especially in the field of chronic illnesses, the engagement of the patient in healthy behaviors, appears to be critical for disease prevention and the optimization of health conditions (9). It is noteworthy that this kind of intervention could reduce the effects of chronic stress and enhance resilience, self-management, and overall quality of life in patients undergoing cancer treatment (9). As a result, clinically developed and validated mHealth tools have the chance to become a personalized medicine tool in health care systems (9). In order to sustain long-term devotion to applications, creators should consider the implementation of engaging elements appealing to the user, such as ease of use, variety of contexts to avoid habituation as well as interactive elements in the early conceptualization of services (6,10-12). While the ultimate goal seems to be the adaptation of engagement strategies, there is little research on their development in mHealth services (12).

METHODS

The major objective of this review is to search the existing design theories incorporating engagement techniques that guided the creation of mHealth interventions applied in adolescents and young adults with cancer. Bibliographical research was conducted focusing on any kind of adolescent cancer and mHealth interventions in various databases. Specifically, most of the included articles come from Scopus, Pubmed, and one from W.H.O.. The present review includes both adolescents and young adults respecting the wide age range of this developmental stage.

RESULTS

The aforementioned research retrieved 40 articles, limited to the English language. The bibliographical research included specific theories that have broadly guided the creation of mHealth services aiming at user support and behavioral change. The present review focuses on Behavior Change Theory, User Centered Design, Social Marketing Theory, Social Cognitive Theory, Self-Determination Theory and Narrative Transportation Theory. The research indicates applied designing components based on theoretical frameworks that result in the successful engagement of mHealth interventions for adolescent cancer patients. In addition, it is supported that users have better possibilities to engage and cooperate with mHealth interventions when elements such as rewards, feedback, personalization, variation, convenience and gamification building design are integrated.

DISCUSSION

Theories

Behavior Change Theory

Researchers indicate that health promotion experts create health interventions, implementing behavior change theories in order to target groups (13). These theories appraise the norms, attitudes, and beliefs that may affect a person's health behavior (13). It is a fact that, although numerous theories exist, each one has a unique set of constructions and can differently affect behavioral modification (13). Studies focusing on the design building of mHealth applications show that optimal user engagement and thus behavior change can be achieved by positive reinforcement techniques such as rewarding the user for actively participating (9,12,14-20).

Persuasive technology (PT) is referring to interactive systems that are successful at encouraging various health and wellness-related behaviors by modifying and reinforcing the behavior and/or attitude (16). The model presents four categories of behavior change support features such as primary task support, dialogue support, credibility support, and social support features. (14,17,18). PSD features have an impact on behavior modification by helping the user accomplish the main goal, enabling human-computer interactions with feedback prompts, suggestions, or reminders while demonstrating the integrity of the system, and inspiring users by elevating social influence (16). The PSD model can be used to evaluate and create systems that affect attitudes and behaviors (16-18).

According to Elena Vlahu-Gjorgievska et al. (16) concerning behavioral change, specific PSD features including categories can positively affect health-related behavioral changes. Researchers indicate that application designers should take into account the proper software design elements that will direct users toward the required attitude or behavior change aiming for effective management of patients' healthcare (16-18).

User-Centered Design

Studies present that User-Centered Design (UCD) is an interactive design method that involves users throughout the whole process of product creation (13). In order to optimize the usefulness of the final product, it is supported that a user-centered strategy which includes users in every stage, a multidisciplinary team, attentive and professional management, and identification of user's goals and objectives seem to be necessary (10). A requirements' analysis is the first step in the interactive cycles comprising in user-centered app design (6,12). In addition, UCD examines technology's acceptability, feasibility, and usability in the user's regular context (13). When implying this design technique, the designer should ensure that the user can utilize the finished product as intended while conveniently learning the usage (13). It is worth noting that nearly all applications have incorporated user feedback using the means of discussion and creation of interdisciplinary teams (10).

Studies indicate that the central idea of UCD is expanded by the procedure of cocreation (19,20). Cocreation design method enables the target audience of the finished product to make important decisions, incorporating users' voices in the application's design and content (20). The cocreation process can provide a user-friendly software that will be useful and pleasant for the intended patient audience (20). This enables young people who intend to use the application, to actively participate in the development of their own final product, sharing suggestions and experiences while also shifting the concentration from professional stakeholders to those who would actually use the finished product (19,20).

Social Marketing Theory

Social marketing applies classical marketing strategies to persuade people to engage in healthier activities (13,12). It is most effective when applied as a research-driven approach that incorporates end-user feedback in order to develop a customized campaign for a particular audience (13). When developing health campaigns, social marketing is essential since it reflects the audience's perspective

by integrating the "Four P's of Marketing" which include: product, pricing, place, and promotion (13).

Social Cognitive Theory, Self-determination Theory, Narrative Transportation Theory

Bernard et al. (21) argued that the theoretical structure which guided the development of the "Mila Blooms" application was based on social cognitive theory (SCT), self-determination theory (SDT), and narrative transportation theory (NTT). Specifically, increasing self-efficacy for adopting a healthy lifestyle throughout skill development, strengthening behavioral capacities, and enhancing social support are important components of SCT (21,22). On the other hand, SDT places a strong emphasis on the value of autonomy, relatedness (feeling valued by others), and competence in creating internal motivation for behavioral change (21,23). Finally, according to the narrative transportation theory, developing visual imagery for a narrative world and plot is crucial, and owing to this fact, persuasive messages can be more effectively received through a variety of cognitive processing mechanisms (21,24).

Implementations

As aforementioned, many different theories related to psychology, human-computer interaction, and marketing, point out various strategies, that could be included in mHealth interventions, in order to enhance the engagement of the user (12). Firstly, rewards is one of the most famous engaging strategies used, and could be separated into the promotion of both the extrinsic motivation such as getting a funny meme or gift cards, and the intrinsic motivation by the completion of a survey that could help another person (9,12,14,15,21,25-27). More specifically, based on social influence tactics and operant conditioning behavioral principles, it combines correspondingly rewards without special conditions or restrictions and desirable ones (12). What is more, adolescents seem to prefer mHealth tools that include colorful features, multimedia formats such as video and gif, variation of content and easy to use characteristics (2,11,15). For instance, apps that include a big number of steps in order to complete a function, maximize the complexity and minimize the convenience of usage, causing adolescent cancer patients displeasure (2). Novrianda et al.(10) concluded that especially the strategies of ease of use and perceived benefits are considered predicting factors of the actual usage of mHealth technology.

There are many more compelling capabilities that could increase the loyalty of the user to the mHealth interventions (15). Personalization is another very widely used engagement strategy that allows the operation of the system to the favorite preferences of the users, thus improving their satisfaction (2,11,15). More specifically in the field of adolescent cancer, this element offers the possibility of customizing the content (e.g. avatar or app environment), the tools, and the timing of intervention delivery according to the patient's will, enhancing his self-management skills (10,25). Moreover, reports of patients' symptoms in their own words is an implied example of tailored mHealth interventions designed to deliver personal health-related information that even younger populations could benefit from (8,25). Engagement is also boosted by developmentally and culturally acceptable content and graphics, as it focuses on the interests and the needs of targeted users (2,9,15). Another productive technique in mHealth services is the provision of feedback from the user on certain engagement content, for example by adding a thumbs up or thumbs down button (12,15). Lastly, time-appropriate interventions, such as text message delivery, via reinforcement learning algorithms and personalized sensing services seem to assist in long-term engagement (11,15).

Gamification, on the other hand, is a design process that incorporates many engaging strategies along with "gaming elements" like rewards, badges, avatars, and competitions, while also providing capabilities such as social integration, feedback on performance, and positive reinforcement (14,15,26-28). Clinically well-designed videogames for adolescents with cancer seem to promote intrinsic motivation as their content offers autonomous choices, chances for entertainment, shifting of attention, and user empowerment (21,27). "Positive addiction" caused by serious games seems to boost empowerment and resilience in cancer patients, resulting in higher levels of self-management (14,27,28). Heneghan et al.(6) in their research noted that the provision of positive feedback to stress-buffering neurotransmitters is the next stage in developing empowerment skills for patients (6). One extraordinary example of a serious mHealth game aiming at the improvement of patients' perception of chemotherapies, is the "Remission 2" (26). During this videogame cancer patients fight cancer cells using chemotherapy pills, antibiotics, and the body's natural defenses as bullets, resulting in increased positive emotions and self-efficacy (26).

Limitations and further research

The aforementioned theoretical frameworks and the engagement strategies present some worth-mentioning limitations (15). Firstly, it is supported that the majority of mHealth interventions available on the market are not based on a significant theoretical background, and experimental validation (14,15). The safety of consumers, might also be at risk due to the fact that some mHealth applications are not necessarily supported by scientific research (14). Additionally, the majority of the existing applications are lacking in evidence of sustained user engagement (14,15). Additionally, a gap between the scientific and commercial fields seems to exist, as applications that are offered to customers in online stores might not have a scientific base while the scientifically based ones are not accessible to them (15). Lastly, the cocreation design method is presented as a long-duration procedure with decreasing number of patients taking place in every stage (20).

Future research on mHealth design should emphasize appropriate methodological approaches and researches, in order to improve the available technological resources (15). More real-world clinical trial evidence is required and application descriptions ought to be accompanied by ratings of the functional quality and empirical backing (15). Furthermore, it is noted that the collaboration of scientists, software developers, and healthcare professionals is considered a key feature in the creation of high-quality, comprehensive, and commercially applicable mHealth tools for adolescents with cancer (15). In order to help other researchers understand the procedures used in the design of mHealth interventions, experts advise that researchers should give the public access to the development process of mHealth intervention (31).

Last but not least, it is supported that the evaluation of interventions includes qualitative techniques to investigate additional improvements, such as modifications in the technology platforms employed, in order to stay up-to-date with technological advancements (28).

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